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Abstract

The focus of this project is to demonstrate the effectiveness of Amended Silicates™ sorbents as a mercury control technology for coal-fired power plants. The demonstration will be conducted at Cinergy's Miami Fort Unit 6 over a period of about eight weeks under typical plant operating conditions. Several trial campaigns will be completed: a parametric series of injection rates for the Amended Silicates sorbent to characterize its performance at the host site, a parametric series of injection rates for powdered activated carbon to use as a basis of comparison, and an extended period (30 days) over which Amended Silicates sorbent is injected to evaluate long-term performance of the technology in an operating power plant, including impact on balance of plant equipment. Samples of the host unit fly ash mixed with Amended Silicates sorbent will be extracted for testing as a cement replacement. A unique feature of the Amended Silicates sorbent is that its addition to a flue gas stream does not affect the salability of the collected fly ash plus sorbent as a pozzolan additive.

In this fourth quarter of the project, activities focused on coordination with host site personnel to determine locations for sorbent injection lances, mercury measurement ports, and the sorbent feed system at the host site. ASL also successfully negotiated an agreement to add to the project team a strategic partner to manufacture the 50 tons of Amended Silicates sorbent needed for the demonstration trial. Engelhard Corporation, a Fortune 500 company with extensive experience in the manufacture of catalysts, sorbents, and pigments will fill this role on the project team. The addition of Engelhard will result in a modification to the project schedule to accommodate work required to modify the manufacturing process to reduce cost and improve quality and uniformity of the sorbent product. Details of the proposed schedule change will be presented to DOE early in the next quarter.

The preparation of a demonstration plan to guide the field activities was also initiated in the current quarter. This document will be published next quarter.

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Executive Summary

The Amended Silicates™ sorbent technology is a mercury control material that is a direct replacement for activated carbon. Amended Silicates sorbent is a powdered material similar to carbon injected upstream of existing particulate control equipment for rapid and effective capture of vapor-phase mercury in the flue gas stream. This technology has been under development for the past two years with funding from the EPA and DOE, and has achieved success in demonstrating the sorbent at a pilot scale on a slipstream from a Colorado power plant. This demonstration of Amended Silicates™ sorbents will evaluate the use of injected particulate sorbents to control of mercury emissions from Cinergy's Miami Fort Unit 6 for a period of six weeks under various conditions. A consortium has been established to support the technical and financial requirements imposed by a long-term test of this technology. The consortium includes utilities with an interest in cost-effective mercury control technologies, mercury control technology suppliers (i.e., Amended Silicates, LLC and its parent companies); the University of North Dakota Energy and Environmental Research Center to lead the mercury measurement effort; a modeler to provide insight into the fluid mechanics of sorbent injection; with strong interest on the part of EPRI and the American Public Power Association.

The project has been defined in three stages: **preparation**, which incorporates all activities to prepare the host site for the demonstration, as well as the manufacture of 50-100 tons of Amended Silicate™ sorbent; **demonstration**, where a matrix of sorbent injection cases will be conducted; and **analysis**, during which all the collected data will be correlated, analyzed, and interpreted to provide quantitative information regarding the performance of the Amended Silicate™ sorbent at a commercial scale. ADA has established a series of milestones for these three stages as delineated in this report.

In this quarter, work consisted of tasks in the Preparation and Analysis phases of the project. Activities focused on coordinating with the host site to establish locations for sorbent injection and gas-phase mercury measurement as well as for the sorbent injection system hardware. ASL also completed negotiations to add Engelhard Corporation to the project team as a strategic partner for the manufacture of 50 tons of Amended Silicates sorbent for use in the Demonstration trial. Preparation of the Demonstration Plan to guide field activities at the host site was also initiated, with plans to publish the plan in the next quarter.

Introduction

Amended Silicates, LLC, has been awarded a project to demonstrate its Amended Silicates™ mercury removal sorbent technology in a full-scale trial at a coal fired power plant. The trial is to be hosted by Cinergy at a site in Ohio and funded in part by US Department of Energy's National Energy Technology Lab (NETL).

The Amended Silicate™ sorbent technology, a direct replacement for activated carbon, is a powdered sorbent injected upstream of existing particulate control equipment for rapid and effective capture of vapor-phase mercury in the flue gas stream. This technology has been under development for the past two years with funding from the EPA and DOE, and has achieved success in demonstrating the sorbent at a pilot scale on a slipstream from a Colorado power plant.

The Amended Silicate™ sorbents use silicate materials as substrate particles on which a chemical reagent with a strong affinity for mercury and mercury compounds is impregnated. Because of their physical construction, these silicates present extended surface area on each particle combined with an easily-generated particle size of a few microns. This configuration promotes maximum exposure of the chemical amendment to the mercury vapor present in the coal-fired flue gas stream. The base silicate materials typically sell for *4-8¢ per pound*, so they represent a very cost-effective sorbent material. In addition, because of their silicate content, they have been shown to allow the continued sale of fly ash as a pozzolan material. Tests completed by Boral Materials Technologies have indicated that there is no effect on fly ash use in concrete due to the addition of Amended Silicate™ sorbents, in dramatic contrast to the effect of powdered activated carbon injection.

To support EPA's announced intent to regulate the emissions of mercury from coal-fired power plants; NETL solicited proposals and recently has selected eight of those proposals for cost-shared projects to demonstrate mercury control concepts at a commercial scale. The objective of the program is to gather data to document the performance of mercury control technology alternatives when installed and operated at full-scale (100-MW) generating units. One of the selected proposals is for the demonstration of Amended Silicates™ sorbent technology.

This demonstration of Amended Silicate™ sorbents will evaluate the control of mercury emissions from Cinergy's Miami Fort Unit 6 under various conditions. A consortium is being established to support the technical and financial requirements imposed by a long-term test of this technology. The consortium will include utilities with an interest in cost-effective mercury control technologies, especially those that permit continued sale of fly ash as a pozzolan material; mercury control technology suppliers (i.e., Amended Silicates, LLC and its parent companies); an organization to lead the mercury measurement effort; a modeler to provide insight into the fluid mechanics of sorbent injection; and other interested parties. There is strong interest on the part of EPRI and the American Public Power Association in participating in the planned demonstration project.

Amended Silicates, LLC, is a joint venture company formed by ADA Technologies and CH2M HILL that is focused on the manufacture and sale of Amended Silicate™ sorbent. Recently, Amended Silicates, LLC has entered into negotiations with a major materials science company to manufacture the large quantities of Amended Silicate sorbent needed for the demonstration. The Amended Silicates team will lead the technical effort of the proposed project. Cinergy has offered its Miami Fort Unit 6 as a host site, and will provide on-site technical support during injection of the sorbent material. The mercury semi-continuous emissions monitors (SCEMS) will be provided by the University of North Dakota's Energy and Environmental Research Center (UNDEERC), and the Ontario-Hydro wet chemistry testing will be conducted by the Western Kentucky University (WKU). Boral Materials Technologies will perform tests of the collected sorbent plus fly ash to assess the impact of the added sorbent on the use of fly ash as a concrete additive. The ability to continue to sell fly ash is believed to be one of the significant advantages of Amended Silicate™ sorbents in comparison to activated carbon.

Project Description

This trial demonstration project is intended to show the effectiveness of Amended Silicate™ sorbent as a mercury control technology, including the ability to maintain fly ash sales from plants implementing its use. The project will incorporate three sorbent injection campaigns: one where powdered activated carbon is injected for a base-comparison case, a second where Amended Silicates sorbent is injected to establish process parameters required to meet mercury control targets, and a third where Amended Silicate sorbent is injected for a contiguous period of 30 days to validate long-term consistent performance and to discover any impact on balance of plant operation.

There are two major objectives for the full-scale demonstration project. The first is to produce uniform and high-quality Amended Silicate™ sorbent in multi-ton quantities for use in the proposed testing. The second is to demonstrate the ability of Amended Silicate™ sorbent to control emissions of mercury from commercial coal-fired power plants over a typical range of operating conditions for an extended period of time. The data analyses will be extensive, and will include computation of mercury removal rates and the efficiency of Amended Silicate™ sorbents in these applications.

The project has been defined in three stages: **preparation**, which incorporates all activities to prepare the host site for the demonstration, as well as the manufacture of 50-100 tons of Amended Silicate™ sorbent; **demonstration**, where a matrix of sorbent injection cases will be conducted; and **analysis**, during which all the collected data will be correlated, analyzed, and interpreted to provide quantitative information regarding the performance of the Amended Silicate™ sorbent at a commercial scale.

There are specific activities to be carried out in each stage of the project, as described below.

Preparation

- Project planning, including placement of subcontracts with team members and negotiation of a host site agreement with Cinergy.
- Development of a project schedule that reflects availability of the site, subcontractors, and time needed to prepare a commercial quantity of Amended Silicate sorbent.
- Site preparation, including the selection of locations for flue gas sampling ports and sorbent injection ports, and for the installation of a sorbent injection system to supply sorbent to the injection lances.
- Completion of a computational fluid dynamics modeling study to evaluate options for the number and locations of sorbent injection lances.
- Acquisition of a leased sorbent injection skid, fabrication of injection lances, and installation of the full sorbent injection system.
- Transport and installation of the semi-continuous mercury emissions monitors upstream of sorbent injection and at the outlet to the Unit 6 electrostatic precipitator.
- Preparation of 50 tons of Amended Silicate sorbent for use in the trial. This activity includes selection of a toll processor (contract vendor) to manufacture the sorbent, and oversight by Amended Silicates, LLC to assure quality control and consistency of the final product.

Demonstration

In the demonstration phase a series of campaigns will be completed with different sorbents to characterize their performance in capture of mercury from the flue gas of Miami Fort Unit 6. Mercury CEMs will be operated throughout the demonstration phase to collect data on mercury concentrations upstream of sorbent injection and at the outlet of the ESP of the host unit. At four discrete times in the demonstration, Ontario-Hydro wet chemistry sampling will be performed as a check against the mercury CEMs data. The specific mercury removal measurement campaigns are described below.

- Baseline mercury removal characterization for the host unit over a one to two week period.
- Injection of powdered activated carbon as a mercury sorbent on Miami Fort Unit 6. This campaign will run for one to two weeks, with target mercury removal rates of 55% and 80%.
- Injection of Amended Silicate sorbent in a parametric series of trials, to characterize performance in the host unit under a range of operating conditions. Target mercury removal rates will be 55% and 80% for this nominal two-week trial.

- Return to normal operations (no sorbent injection) for a period of one to two weeks to re-establish a baseline before initiation of a longer-term trial of Amended Silicates sorbent.
- Extended trial of Amended Silicate sorbent for a period of 30 days to evaluate performance and impact on balance of plant equipment.
- During each campaign, samples of fly ash mixed with mercury sorbent material will be extracted for use in tests to determine the effect of the sorbent on the use of the mixture as a pozzolan replacement in the manufacture of concrete.

Analysis

The use of CEMS results in the acquisition of a substantial quantity of data over the demonstration phase of the project. This information will be subject to a rigorous QA/QC review protocol, then archived to a project website where it will be accessible to project team members. This website will provide the home for a project database to be used to correlate mercury removal results with operating conditions of the host unit and performance of the particulate control equipment. The intent is to exploit the website to facilitate access to the data on a timely basis throughout the project. Specific activities to be carried out in the Analysis phase are noted below.

- Prepare and execute a QA/QC plan for the project.
- Establish a project website as a mechanism to share information and coordinate analysis of posted results.
- Create a project data base as a location to which all pertinent information on trials can be transferred for secure storage and analysis.
- Perform routine QA/QC screening of data and add qualified data to the project data base.
- Review and analyze trial data in the project data base to establish performance measures and trends in the data set.
- Analyze samples of fly ash plus sorbent to document the effect of sorbent addition on the use of fly ash as a cement replacement in concrete.
- Supply samples of fly ash to DOE contractor for leachate and mercury stability testing.
- Preparation of reports as required by the Cooperative Agreement.
- Preparation of technical papers that document the results of the trial demonstration.
- Overall management of the project with respect to scope, schedule, and budget.

Project activities are being carried out by technical personnel from the two parent companies of Amended Silicates, LLC. Jim Butz of ADA Technologies serves as Principal Investigator for the project with strong technical support from CH2M HILL and the other members of the consortium. Tom Broderick of ADA will serve as the lead engineer for the project team at the host site during the trial. Joe Hammond of CH2M HILL will direct the site engineering activity for the installation of the sorbent injection system and mercury CEMs.

Project Milestones

Amended Silicates, LLC recently completed negotiations to add a strategic partner to the project team to manufacture the Amended Silicate sorbent material for the demonstration. Engelhard Corporation is a Fortune 500 company that manufactures and sells catalysts, pigments, and sorbents, many on natural mineral substrates into markets worldwide. Engelhard has signed a joint development agreement, and will negotiate a license to manufacture and sell Amended Silicates™ sorbent for the removal of mercury from combustion flue gas streams. As a result of this agreement the milestones dates have changes as shown below. The first activity to be carried out under the JDA is an intense review of the sorbent preparation protocol with a focus on unit processes where Engelhard manufacturing experts believe small changes can improve quality and reduce cost. This short-term effort is already under way, and is planned for completion by 1 August, 2005.

The milestones below have been recently proposed to DOE as a modification to the previous schedule, and are now under review.

- **April, 2004:** Cooperative agreement signed by Amended Silicates, LLC and project initiated.
- **August, 2004:** Subcontracts in place, project team coordinates schedule.
- **March, 2005:** Joint Development agreement negotiated with Engelhard Corporation to become strategic manufacturing partner to Amended Silicates, LLC.
- **April 2005:** Engelhard begins preparation of sorbent samples to evaluate process step impact on final sorbent product. Short-term cooperative effort between ADA and Engelhard technical staffs initiated.
- **July 2005:** Production process modifications identified for preparation of 50 tons of Amended Silicates sorbent to be used in Cinergy demo.
- **August 2005:** Scale-up production trial to manufacture nominal 2,000-lb quantity.
- **October 2005:** Begin full-scale production of Amended Silicates sorbent.
- **December 2005:** Deliver Amended Silicates sorbent to Miami Fort Station.
- **First Quarter, 2006:** Begin injection trial.

- **Second Quarter 2006:** Submit samples of fly ash plus sorbent for analysis of suitability for use in concrete.
- **Second Quarter 2006:** Samples provided for leachate and stability testing.
- **July 2006:** Data analyses completed.
- **Second half of 2006:** Presentation of results at technical conferences.

Project Management Activities This Quarter

This report documents Amended Silicates project activities from January 1 through March 31, 2005. For this period, work consisted of tasks in the Preparation phase and Analysis phase. Activities focused on meeting with technical personnel from the host site for the project (Cinergy's Miami Fort Unit 6) and securing a strategic partner who will manufacture the Amended Silicate sorbent material for the demonstration.

Additional discussions were held with the host site regarding planning for 2005 site activities. A February meeting at the Miami Fort generating station offered an opportunity to perform a walk-through of the site to review options for the locations of sorbent injection ports on the host unit ductwork, sampling ports to extract flue gas for the measure of mercury concentrations before and after injection of the Amended Silicates sorbent, and the location of the sorbent injection skid. An array of four ports were discovered just downstream of the air heater outlet on Unit 6, which were judged to be candidates for use as sorbent injection locations. It was agreed that ASL would arrange for another case to be run of the CFD model for sorbent distribution where these ports were used for sorbent injection. If model results are positive, use of existing ports would save cost and time required to install new injection ports downstream in the ductwork.

Technical staff from WKU visited the site later in the quarter to consider the feasibility of a location for outlet mercury sampling identified during the ASL visit in February. The WKU team affirmed the suitability of the location at the outlet of the ESP box on Unit 6, and worked with Miami Fort engineering staff to identify inlet mercury sampling locations as well. Both inlet and outlet vapor-phase mercury sampling ports were specified with provision for simultaneous S-CEM and Ontario-Hydro sampling. The Ontario-Hydro sampling protocol requires traversing the ductwork via multiple sampling ports.

During the site visit at Miami Fort, the question of permits that may be required for the trial was raised with Cinergy personnel. Mr. Mike Geers, the Cinergy corporate contact for this demonstration project, subsequently contacted local pollution control authorities and was advised that simple notification of plans for the trial would be sufficient. Cinergy also questioned the impact of the injection of sorbent on suspended solids in the host unit ash ponds. It was decided that a simple test would be worth completing. Cinergy forwarded a sample of the ash pond water to ADA for use in a lab test to determine if the addition of either activated carbon or Amended Silicates sorbent had any effect on suspended solids in the ash pond water sample. ADA will conduct those tests in the next quarter.

In this quarter Amended Silicates, LLC completed negotiations with Engelhard Corporation, an international chemical and catalyst manufacturing firm, to become a strategic partner for the manufacture of the 50 tons of Amended Silicates sorbent needed for the demonstration. Engelhard brings to the project extensive and broad expertise and experience in the preparation of materials- catalysts, sorbents, and pigments- which are based on the use of commodity minerals as substrates to which chemical treatments are applied. Engelhard has assigned production engineering as well as research personnel to a joint effort to refine the manufacturing process for Amended Silicates to reduce cost and improve quality. Advancement in improving the manufacturing process is critical to commercial success of Amended Silicates in the marketplace; for this reason, the addition of Engelhard to the project team is a significant step forward for Amended Silicates, LLC.

In light of the proposed schedule change, ADA will lead an effort to evaluate the budget to confirm that the proposed demonstration project can be completed within the existing budget allocation from DOE and cost-share partners. This evaluation will be completed in the next quarter.

Work was begun this quarter on the Miami Fort Demonstration Plan. The demonstration plan of an earlier DOE mercury control project was used as a template. The Site Description section was expanded to include a schematic of the ESP layout for Unit 6. This schematic helps to illustrate the configuration and interconnectivity of the three ESPs installed on the host unit. The locations and description of the mercury sampling ports was also input to the plan. The demonstration protocols for both Amended Silicate and activated carbon injection trials were developed and incorporated into the plan. The waste characterization section was also input to reflect the testing that will be done with fly ash materials taken during the short-term and long-term sorbent injection trials with the Amended Silicate sorbent. Sampling methodology for the fly ash reflects experience gained in during the short–term injection trial of Amended Silicates sorbent last year at Xcel Energy's Arapahoe station.

Experimental

No activities in this phase of the project were conducted this quarter.

Results and Discussion

There are no results or discussion to report this quarter.

Conclusions

There are no conclusions to report this quarter.

References

None.

Bibliography

None.

List of Acronyms and Abbreviations

ADA	ADA Technologies, Inc.
ASL	Amended Silicates, LLC
CEM	Continuous Emissions Monitor
CFD	Computational Fluid Dynamics
CH2	CH2M HILL
DOE	Department of Energy
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESP	Electric Static Precipitator
NETL	National Energy Technology Laboratory
QA/QC	Quality Assurance/Quality Control
SCEM	Semi- Continuous Emissions Monitor
UNDEERC	University of North Dakota's Energy and Environmental Research Center
US	United States
WKU	Western Kentucky University

Planned Activities for Next Quarter

The next quarter of the project will see continued efforts in the design and planning phases, including the following elements:

- A focused cooperative effort to finalize the large-scale manufacturing protocol with new strategic partner Engelhard Corporation. The intent here is to have a protocol ready for evaluation in a pilot run of a few thousand pounds of Amended Silicates sorbent in August of 2005.
- Prepare a revised schedule for submittal to DOE for approval. Review budget to confirm that current funding is sufficient to complete project. ADA is responsible for this effort.
- Complete negotiations and sign a host site agreement with Cinergy Services. ADA will lead this effort.
- Complete preparation of the test plan and associated sampling protocols. ADA Technologies to lead this effort.
- Finalize location at the host site for the sorbent injection ports, sorbent feed system, and routing of sorbent supply lines. ADA and Cinergy to coordinate these decisions.
- Prepare reports to meet requirements of the cooperative agreement. ADA Technologies to complete these reports.